

What is claimed is:

1. An etching method for use in integrated circuit fabrication, the method comprising the steps of:

- 5 providing a metal nitride layer on a substrate assembly;
providing regions of cobalt silicide on first portions of the metal nitride layer;
providing regions of cobalt on second portions of the metal nitride layer; and
removing the regions of cobalt and the second portions of the metal nitride layer
with at least one solution including a mineral acid and a peroxide.

10 2. The method according to claim 1, wherein the mineral acid is selected from the group including HCl, H₂SO₄, H₃PO₄, HNO₃, and dilute HF.

3. The method according to claim 2, wherein the mineral acid is HCl.

15 4. The method according to claim 1, wherein the peroxide is hydrogen peroxide.

5. The method according to claim 1, wherein the removing step includes removing the regions of cobalt and the second portions of the metal nitride layer with a single solution including a mineral acid and a peroxide.

20 6. The method according to claim 1, wherein the removing step includes:
removing the regions of cobalt with a first solution containing a mineral acid and a peroxide; and
removing the second portions of the metal nitride layer with a second solution
25 containing a peroxide.

7. An etching method for use in integrated circuit fabrication, the method comprising the steps of:

providing a metal nitride layer on a substrate assembly;

providing regions of cobalt silicide on first portions of the metal nitride layer;
providing regions of cobalt on second portions of the metal nitride layer; and
removing the regions of cobalt and the second portions of the metal nitride layer
with a solution including a mineral acid and a peroxide.

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8. The method according to claim 7, wherein the mineral acid is selected from the
group including HCl, H₂SO₄, H₃PO₄, HNO₃, and dilute HF.

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9. The method according to claim 8, wherein the mineral acid is HCl.

10. The method according to claim 7, wherein the peroxide is hydrogen peroxide.

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11. The method according to claim 7, wherein the solution includes a ratio in a range
of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral
acid:peroxide:deionized water).

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12. The method according to claim 11, wherein the solution includes a ratio in a
range of about 1:1:25 (mineral acid:peroxide:deionized water) to about 1:1:10 (mineral
acid:peroxide:deionized water).

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13. An etching method for use in integrated circuit fabrication, the method
comprising the steps of:

providing a metal nitride layer on a substrate assembly;
providing regions of cobalt silicide on first portions of the metal nitride layer;
providing regions of cobalt on second portions of the metal nitride layer;
removing the regions of cobalt with a first solution containing a mineral acid; and
removing the second portions of the metal nitride layer with a second solution
containing a peroxide.

14. The method according to claim 13, wherein the mineral acid is selected from the group including HCl, H₂SO₄, H₃PO₄, HNO₃, and dilute HF.

15. The method according to claim 14, wherein the mineral acid is HCl.

16. The method according to claim 13, wherein the peroxide is hydrogen peroxide.

17. The method according to claim 13, wherein the first solution includes a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water).

18. The method according to claim 17, wherein the first solution includes a ratio in a range of about 1:1:200 (mineral acid:peroxide:deionized water) to about 1:1:100 (mineral acid:peroxide:deionized water).

19. The method according to claim 13, wherein the second solution includes a ratio in a range of about 1:50 (peroxide:deionized water) to about 1:1 (peroxide:deionized water).

20. The method according to claim 19, wherein the second solution includes a ratio in a range of about 1:10 (peroxide:deionized water) to about 1:5 (peroxide:deionized water).

21. The method according to claim 13, wherein the second solution includes a ratio in a range of about 0.05:1:6 (mineral acid:peroxide:deionized water) to about 1:1:6 (mineral acid:peroxide:deionized water).

22. An etching method for use in integrated circuit fabrication, the method comprising the steps of:

providing a titanium nitride layer on a substrate assembly;
providing regions of cobalt silicide on first portions of the titanium nitride layer;
providing regions of cobalt on second portions of the titanium nitride layer; and
removing the regions of cobalt and the second portions of the titanium nitride
5 layer with a solution including a mineral acid and a peroxide.

22. The method according to claim 21, wherein the mineral acid is HCl and the peroxide is hydrogen peroxide.

10 23. The method according to claim 22, wherein the solution includes a ratio in a range of about 1:1:35 (HCl:hydrogen peroxide:deionized water) to about 1:1:5 (HCl:hydrogen peroxide:deionized water).

24. An etching method for use in integrated circuit fabrication, the method
15 comprising the steps of:
providing a titanium nitride layer on a substrate assembly;
providing regions of cobalt silicide on first portions of the titanium nitride layer;
providing regions of cobalt on second portions of the titanium nitride layer;
removing the regions of cobalt with a first solution containing a mineral acid and
20 a peroxide; and
removing the second portions of the titanium nitride layer with a second solution containing a peroxide.

25. The method according to claim 24, wherein the mineral acid of the first solution
25 is HCl and the peroxide is hydrogen peroxide.

26. The method according to claim 24, wherein the first solution includes a ratio in a range of about 1:1:300 (HCl:hydrogen peroxide:deionized water) to about 1:1:70 (HCl:hydrogen peroxide:deionized water).

27. The method according to claim 24, wherein the peroxide of the second solution is hydrogen peroxide.

5 28. The method according to claim 27, wherein the second solution includes a ratio in a range of about 1:50 (peroxide:deionized water) to about 1:1 (peroxide:deionized water).

10 29. A method for use in patterning a stack including cobalt silicide, the method comprising the steps of:
providing a layer of cobalt, regions of silicon, and a conductive diffusion barrier;
reacting the layer of cobalt and regions of silicon using thermal processing
resulting in the stack including cobalt silicide and the conductive diffusion barrier and
further resulting in unreacted cobalt overlying removable regions of the conductive
diffusion barrier; and
15 removing the unreacted cobalt and removable regions of the conductive diffusion barrier using at least one solution including a mineral acid and a peroxide.

20 30. The method according to claim 29, wherein the removing step includes removing the unreacted cobalt using a first solution including a mineral acid and a peroxide with the removable regions of the conductive diffusion barrier being an etch stop.

25 31. The method according to claim 30, wherein the removing step further includes removing the removable regions of conductive diffusion barrier using a second solution including a peroxide.

32. The method according to claim 29, wherein the mineral acid is HCl and the peroxide is hydrogen peroxide.

33. A method for use in integrated circuit fabrication, the method comprising the steps of:

- 5 providing a metal nitride layer on a substrate assembly;
providing a layer of cobalt on the metal nitride layer;
providing a layer of silicon on the cobalt layer;
patterning the silicon layer resulting in exposed portions of cobalt and unexposed portions of cobalt;
performing a thermal treatment to form cobalt silicide from the unexposed portions of cobalt over first portions of the metal nitride layer with unreacted cobalt
10 resulting over second portions of the metal nitride layer; and
removing the unreacted cobalt and the second portions of the metal nitride layer with at least one solution including a mineral acid and a peroxide.

34. The method according to claim 33, wherein the removing step includes removing
15 the unreacted cobalt and the second portions of the metal nitride layer with a single solution including HCl and hydrogen peroxide.

35. The method according to claim 33, wherein the removing step includes:
20 removing the unreacted cobalt with a first solution including HCl and hydrogen peroxide; and
removing the second portions of the metal nitride layer with a second solution including hydrogen peroxide.

36. An etching composition, the composition comprising a mineral acid, a peroxide,
25 and deionized water.

37. The etching composition according to claim 36, wherein the mineral acid is HCl and the peroxide is hydrogen peroxide.

38. The composition according to claim 36, wherein the composition includes a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water).

5 39. The composition according to claim 38, wherein the composition includes a ratio in a range of about 1:1:25 (mineral acid:peroxide:deionized water) to about 1:1:10 (mineral acid:peroxide:deionized water).

10 40. A method of forming a word line for a memory device, the method comprising the steps of:

selectively oxidizing the surface of a substrate assembly to form at least one active area and field oxide regions;

forming a gate film in the active area;

forming a conductive silicon layer over the gate film;

15 forming a metal nitride layer over the conductive silicon layer;

forming a cobalt layer over the metal nitride layer;

forming a layer of silicon over the cobalt layer;

forming a cap layer over the layer of silicon;

20 patterning the cap layer and layer of silicon over first portions of the cobalt layer overlying first portions of the metal nitride layer to define the word line at least in part over the gate film in the active area of the memory device while exposing second portions of the cobalt layer overlying second portions of the metal nitride layer;

performing an anneal to react the first portions of the cobalt layer with the layer of silicon;

25 removing the second portions of cobalt and the second portions of the metal nitride layer with at least one solution including a mineral acid and a peroxide, such removal resulting in exposed portions of the conductive silicon layer; and

removing the exposed portions of the conductive silicon layer.

41. The method according to claim 40, wherein the step of removing the second portions of cobalt silicide and metal nitride layer includes removing the second portions of cobalt and the second portions of the metal nitride layer with a single solution including HCl and hydrogen peroxide.

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42. The method according to claim 40, wherein the step of removing the second portions of cobalt silicide and metal nitride layer includes:

removing the second portions of cobalt with a first solution including HCl and hydrogen peroxide; and

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removing the second portions of the metal nitride layer with a second solution including hydrogen peroxide.

43. A method of forming a local interconnect for a memory device, the method comprising the steps of:

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selectively oxidizing the surface of a substrate to form one or more active areas and field oxide regions;

forming a gate region, source region, and drain region in the one or more active areas;

forming one of at least a portion of a bit line and a word line; and

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forming an interconnect to connect at least two of the gate region, source region, drain region, bit line, and word line, the forming of the interconnect step comprising the steps of:

forming a metal nitride layer over at least an oxide provided between the at least two of the gate region, source region, drain region, bit line, and word line,

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forming a cobalt layer over the metal nitride layer,

forming a layer of silicon over the cobalt layer,

patterning the layer of silicon over first portions of the cobalt layer overlying first portions of the metal nitride layer to define the interconnect while

exposing second portions of the cobalt layer overlying second portions of the metal nitride layer,

performing an anneal to react the first portions of the cobalt layer with the patterned layer of silicon, and

5 removing the second portions of cobalt and the second portions of the metal nitride layer with at least one solution including a mineral acid and a peroxide.

10 44. The method according to claim 43, wherein the removing step includes removing the second portions of cobalt and the second portions of the metal nitride layer with a single solution including HCl and hydrogen peroxide.

15 45. The method according to claim 43, wherein the removing step includes:
removing the second portions of cobalt with a first solution including HCl and hydrogen peroxide; and
removing the second portions of the metal nitride layer with a second solution including hydrogen peroxide.

Sub C1 46. An etching method for use in integrated circuit fabrication, the method comprising:

providing a substrate assembly comprising a metal nitride region and a cobalt silicide region; and

5 selectively etching a portion of the metal nitride region against the cobalt silicide region using a solution comprising a peroxide, wherein the solution etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute.

10 47. The method according to claim 46, wherein providing the substrate assembly comprising the metal nitride region and the cobalt silicide region comprises:

forming a metal nitride layer; and

forming the cobalt silicide region on at least a first portion of the metal nitride layer.

15 48. The method according to claim 47, wherein forming the cobalt silicide region on at least the first portion of the metal nitride layer further comprises:

contacting a cobalt layer with a patterned silicon layer; and

siliciding the cobalt layer using the patterned silicon layer.

20 49. The method according to claim 48, wherein contacting the cobalt layer with the patterned silicon layer further comprises:

forming the cobalt layer on the metal nitride layer;

forming a silicon layer on the cobalt layer; and

25 patterning the silicon layer.

50. The method according to claim 46, wherein the solution further comprises a mineral acid.

Sub C2 30 51. The method according to claim 50, wherein the mineral acid comprises at least

one mineral acid selected from a group consisting of HCl, H₂SO₄, H₃PO₄, HNO₃, and dilute HF.

52. The method according to claim 51, wherein the mineral acid comprises HCl.

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Sub (3) 53. The method according to claim 50, wherein the solution comprises a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water).

10 54. The method according to claim 53, wherein the solution comprises a ratio in a range of about 1:1:25 (mineral acid:peroxide:deionized water) to about 1:1:10 (mineral acid:peroxide:deionized water).

Sub (4) 15 55. The method according to claim 50, wherein the solution comprises a ratio in a range of about 0.05:1:6 (mineral acid:peroxide:deionized water) to about 1:1:6 (mineral acid:peroxide:deionized water).

20 56. The method according to claim 55, wherein the solution comprises a ratio in a range of about 0.1:1:6 (mineral acid: peroxide:deionized water) to about 0.5:1:6 (mineral acid:peroxide:deionized water).

57. The method according to claim 46, wherein the peroxide comprises hydrogen peroxide.

25 58. The method according to claim 46, wherein the solution comprises a ratio in a range of about 1:50 (peroxide:deionized water) to about 1:1 (peroxide:deionized water).

59. The method according to claim 58, wherein the solution comprises a ratio in a range of about 1:10 (peroxide:deionized water) to about 1:5 (peroxide:deionized water).

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60. An etching method for use in integrated circuit fabrication, the method comprising:

providing a substrate assembly comprising a metal nitride region and a cobalt region; and

5 selectively etching the cobalt region against the metal nitride region using a solution comprising a mineral acid and a peroxide.

61. The method according to claim 60, wherein the mineral acid comprises at least one mineral acid selected from a group consisting of HCl, H₂SO₄, H₃PO₄, HNO₃, and dilute HF.

62. The method according to claim 61, wherein the mineral acid comprises HCl.

63. The method according to claim 60, wherein the peroxide comprises hydrogen peroxide.

64. The method according to claim 60, wherein the solution comprises a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water).

65. The method according to claim 64, wherein the solution comprises a ratio in a range of about 1:1:200 (mineral acid:peroxide:deionized water) to about 1:1:100 (mineral acid:peroxide:deionized water).

66. The method according to claim 60, wherein selectively etching the cobalt region against the metal nitride region further comprises selectively etching the cobalt region against the metal nitride region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute.

67. The method according to claim 60, wherein selectively etching the cobalt region

against the metal nitride region further comprises selectively etching the cobalt region against the metal nitride region at an etch rate in a range of about 100 Å/minute to about 200 Å/minute.

5 68. An etching method for use in integrated circuit fabrication, the method comprising:

 providing a substrate assembly comprising a metal nitride region;
 forming a cobalt region on a first portion of the metal nitride region;
 forming a cobalt silicide region on a second portion of the metal nitride region;

10 and

 selectively etching the cobalt region against the cobalt silicide region stopping on the first portion of the metal nitride region using a solution comprising a mineral acid and a peroxide.

15 69. The method according to claim 68, wherein the mineral acid comprises at least one mineral acid selected from a group consisting of HCl, H₂SO₄, H₃PO₄, HNO₃, and dilute HF.

20 70. The method according to claim 69, wherein the mineral acid comprises HCl.

25 71. The method according to claim 68, wherein the peroxide comprises hydrogen peroxide.

30 72. The method according to claim 68, wherein the solution comprises a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water).

35 73. The method according to claim 72, wherein the solution comprises a ratio in a range of about 1:1:200 (mineral acid:peroxide:deionized water) to about 1:1:100 (mineral acid:peroxide:deionized water).

74. The method according to claim 68, wherein selectively etching the cobalt region against the cobalt silicide region further comprises selectively etching the cobalt region against the cobalt silicide region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute.

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75. The method according to claim 68, wherein selectively etching the cobalt region against the cobalt silicide region further comprises selectively etching the cobalt region against the cobalt silicide region at an etch rate in a range of about 100 Å/minute to about 200 Å/minute.

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